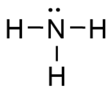
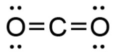
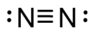
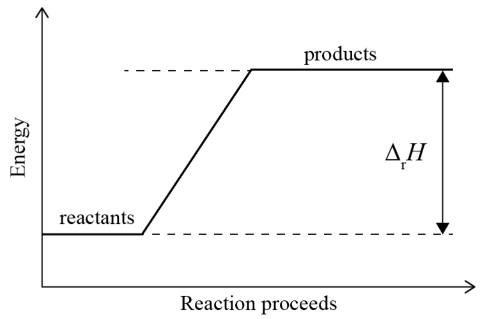
Assessment Schedule – 2022

Chemistry: Demonstrate understanding of bonding, structure, properties and energy changes (91164)

Evidence

<table>
<tr><th>Q</th><th>Evidence</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr><td>ONE
(a)</td><td><table>
<tr><td>Molecule</td><td>NH_3</td><td>CO_2</td><td>N_2</td></tr>
<tr><td>Lewis diagram</td><td></td><td></td><td></td></tr>
<tr><td>Name of shape</td><td>trigonal pyramid</td><td>linear</td><td>linear</td></tr>
</table></td><td>• Three Lewis structures.
OR
Three shapes correct.</td><td></td><td></td></tr>
<tr><td>(b)</td><td>Freon-11 has 4 regions of electron density around the central carbon atom, while sulfur dioxide has 3 regions around the central sulfur atom. In both molecules these regions of electron density repel to maximum separation. This gives freon-11 a tetrahedral parent geometry and bond angles of 109.5°, while sulfur dioxide has a parent geometry of trigonal planar and bond angles of 120°. As all regions in freon-11 are bonding regions the overall shape is tetrahedral, while in sulfur dioxide two of the regions are bonding regions, while one is non-bonding, giving it an overall shape of bent.</td><td>• Identifies the correct number of bonding and non-bonding regions for ONE molecule.
• Recognises electron density regions arranged in position of max separation / min repulsion.</td><td>• Links total number of bonding regions to parent geometry and bond angle for ONE molecule using repulsion theory.</td><td>• Justifies shape of both molecules with reference to all relevant factors.</td></tr>
</table>

(c)(i)		• Diagram shows products with more energy than reactants.	• Diagram correct with labels	
(ii)	In order to evaporate, the attractive forces between freon-11 molecules need to be broken. The breaking of attractive forces is an endothermic process, so energy is absorbed for this to occur. This absorbed energy comes from the heat energy of the surroundings, causing the temperature of the refrigerator to decrease.	• Identifies attractive forces need to be broken. OR Heat energy is absorbed.	• Links breaking of attractive forces to absorption of heat energy.	• Fully explains cooling effect of freon-11 evaporation.

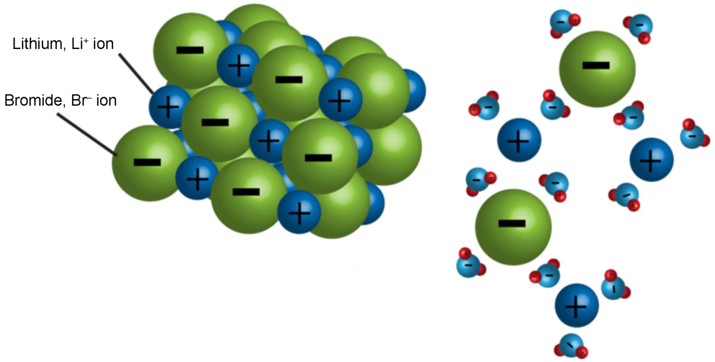
NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response. no relevant evidence.	1a	2a	3a	4a	2m	3m	2e with minor error	2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)(i)	Bonds broken: $4 \times$ C–Cl = $4x$ $1 \times$ H–F = 567 **Total: 567 + 4*x* kJ mol^{-1}** Bonds formed: $3 \times$ C–Cl = $3x$ $1 \times$ C–F = 485 $1 \times$ H–Cl = 431 kJ mol^{-1} **Total: 916 + 3*x* kJ mol^{-1}** Δ_rH = Σbond energies (bonds broken) – Σbond energies (bonds formed) $-21 = 567 + 4x - (916 + 3x)$ $-21 = -349 + x$ $x = 328$ kJ mol^{-1} *Can also be solved using net number of C–Cl bonds.*	• Correctly calculates bonds broken or bonds formed OR Correct process with a major error (e.g., rearranging equation, missing a bond type).	• Correct process with a minor error (e.g., counting bonds, incorrect sign).	• Correct answer with unit.
(ii)	CCl_3F – polar CCl_4 – non-polar	• Identifies polarity of both molecules.		
(iii)	Both freon-11 and carbon tetrachloride have tetrahedral shapes. Both molecules contain polar C–Cl bonds due to the difference in electronegativity between the two atoms, while freon-11 also contains a polar C–F bond. Due to the symmetry of carbon tetrachloride, the dipoles cancel out and the molecule is non-polar. In freon-11, despite the tetrahedral shape, the difference in polarity of the C-Cl and C–F bonds mean the different (sized) bond dipoles cannot cancel out. This means freon-11 is a polar molecule.	• Identifies a difference in electronegativity between atoms. OR Identifies bond dipole cancellation in one molecule.	• Links symmetry / asymmetry of dipole arrangement to dipole cancellation in one molecule.	• Compares and contrasts polarity of both molecules, with reference to electronegativity differences between atoms
(b)	$n(O_3) = \frac{m}{M} = \frac{126}{48} = 2.625$ mol Energy = $\Delta_rH \times n = \frac{285}{2} \times 2.625 = 374$ kJ released	• One step of process correct.	• Correct answer.	

(c)(i) (ii)	Molecular Compound A is a molecular substance which has weak intermolecular forces existing between molecules. As these forces of attraction are weak, at room temperature there is sufficient heat energy to break them, allowing the substance to evaporate.	• Identifies molecular. AND Identifies boiling point is related to strength of attractive forces. OR Identifies intermolecular forces present.	• Links strength of intermolecular forces to low energy requirement for evaporation	

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response. no relevant evidence.	1a	2a	3a	4a	3m	4m	2e with minor error	2e

<table>
<tr><th>Q</th><th>Evidence</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr><td>THREE
(a)</td><td>
<table>
<tr><th>Solid</th><th>Type of solid</th><th>Type of particle</th><th>Attractive forces between particles</th></tr>
<tr><td>Freon-11 $CCl_3F(s)$</td><td>Molecular</td><td>Molecules</td><td>Intermolecular forces</td></tr>
<tr><td>Diamond $C(s)$</td><td>Covalent network</td><td>Atoms</td><td>Covalent bonds</td></tr>
<tr><td>Lithium bromide $LiBr(s)$</td><td>Ionic</td><td>Ions</td><td>Ionic bonds</td></tr>
</table>
</td><td>• Two rows or two columns correct.</td><td>• Table correct.</td><td></td></tr>
<tr><td>(b)</td><td>In order to conduct electricity, a substance must possess charged particles that are free to move.
Diamond is made up of a 3D-network of carbon atoms covalently bonded to each other (in a tetrahedral array). Each carbon is bonded to 4 others. This means there are no valence electrons free to move throughout the structure, and diamond does not conduct electricity.
Graphite is a 2D-covalent network substance. It consists of layers of carbon atoms, bound in hexagonal rings by strong covalent bonds. Each carbon is bonded to 3 others. This means there are (delocalised) valence electrons free to move throughout the structure, allowing graphite to conduct electricity.</td><td>• Describes structure of diamond.
OR
Graphite.
• Identifies mobile free charged particles are required for conductivity.</td><td>• Links conductivity / non-conductivity to presence / absence of free valence electrons in substance.</td><td>• Comprehensively explains conductivity of diamond and graphite.</td></tr>
</table>

(c)(i)	Exothermic. Because the change in enthalpy ($\Delta_r H$) is negative / heat energy is released / products have less energy than reactants / bonds broken.	• Correct reaction type with reason.		
(ii)	$n(\text{LiBr}) = 20/86.8 = 0.230$ mol Energy $= n \times \Delta_r H = 0.230 \times 48.8 = 11.2$ kJ $n(\text{KBr}) = \dfrac{E}{\Delta_r H} = \dfrac{11.2}{19.9} = 0.563$ mol $m(\text{KBr}) = n \times M = 0.563 \times 119 = 67.0$ g	• Correct number of moles of LiBr. OR Correct mass of KBr from incorrect number of moles.	• Correct energy change OR Correct mass of KBr from incorrect energy change.	• Correct mass of KBr calculated.
(iii)	The dissolution of LiBr is exothermic so the solution will be warm, while the dissolution of KBr is endothermic so the solution will be cool.	• Correctly identifies LiBr solution is warm while KBr is cool	• Correctly links **endo / exothermic** nature of processes to temperature of solutions.	
(iv)	Lithium bromide is an ionic compound. When placed in water, the negative pole of water molecules attract the positive lithium (Li^+) ions, and the positive pole attracts the negative bromide (Br^-) ions. The strength of this attractive force is sufficiently strong to overcome the ionic bonds within the ionic lattice, allowing the lattice to be broken down, and LiBr to dissolve.  Adapted from: www.saddlespace.org/whittakerm/science/cms_page/view/7795247	• Identifies attractions are required between water and the substance (LiBr) for it to be soluble. OR Diagram shows water dissolving ionic solid with hydrated ions.	• Links relative strength of the attractive forces between water and the ions in LiBr to solubility.	• Fully justifies solubility of LiBr with use of diagram to illustrate answer.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response. no relevant evidence.	1a	2a	3a	4a	3m	4m	2e	3e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8– 13	14 – 18	19 – 24